RELATIONSHIP BETWEEN DIVE AND POST-DIVE PAUSE WHILE FORAGING IN TWO DIVING DUCKS OF LAKE MANSAR[1]

Y.R. MALHOTRA[2], N. DESKYONG[3], P.S. PATHANIA[3]

(*With three text-figures*)

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Relation between dive and post-dive pause while foraging is quantified in the two diving duck species: Common pochard (*Aythya ferina*) and Tufted duck (*A. fuligula*) that winter in Lake Mansar, Distt. Udhampur, J&K. A total of 1641 dive cycles (981 dive cycles for Tufted duck and 660 for Common pochard) were observed during the winter 1992-93. In both the species positive relationship between dive time and post-dive pause has been analysed by Karl Pearson's Co-efficient of correlation (r) method. However, such positive relationship is more in Common pochard (r=0.88; t>0.05) than in Tufted duck (r=0.65; t>0.05). This has been correlated with the diet difference of the two ducks. Common pochard which is largely a vegetarian shows increase in pause time with dive time as compared to Tufted duck which feeds on sessile or slow moving benthic prey.

Long dives (21 sec. and above) are observed more in Tufted duck than Common pochard. This difference in dive time is influenced by diet difference and foraging decisions made while underwater.

INTRODUCTION

Foraging style of diving birds, that dive from surface of water and after spending some time underwater, returns to the water surface to breathe is well known (e.g., Johnsgard 1965, Wallace and Mahan 1975, Ali and Ripley 1978, Lessells and Stephens 1983, Ydenberg 1986, Woakes and Butler 1986). Similarly considerable literature on physiology of diving is also available. Butler and Jones (1982) in their review "Comparative physiology of diving in Vertebrates" listed almost one thousand references. In contrast, publications of diving behaviour and particularly on the relationship between dive and pause is very scarce.

Diving behaviour of birds hold great fascination not only among ornithologists but also among naturalists and this can be summed up from a Scottish physician and naturalist J.M. Dewar's (1924) statement: "Among the problems surrounding the life of birds, none is more fascinating than the underwater activities of diving fowl".

In this paper, we describe briefly some of our studies on the comparative relationship between dive length and post-dive pause when freely foraging, in the two *Aythya* species, i.e. Tufted duck *A. fuligula* and common pochard *A. ferina,* that winter in lake Mansar. The starting point is the common place observation that although some dives by birds are made during courtship or to escape predators, most are made to capture food.

STUDY AREA

Lake Mansar (32°42' N and 75° E) is a heart shaped sub-oval water body, 65 km to the east of Jammu city (J&K), and is located at an elevation of 710 m above msl. The lake is 37 metres deep at the centre, and has a circumference of 3.294 Km. It is primarily fed by surface run off, and has some submerged spring sources. It is classified as a fault basin, non-drainage, type of lake without any distinct regular inflow or outflow channel.

The lake is utilized by a number of migratory aquatic birds in winter.

METHODS

This study was conducted during the winter of 1992-93 in a lake Mansar. Birds were watched

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[2]Vice-Chancellor, University of Jammu, Jammu (J&K)-180 004.
[3]Post-Graduate Department of Bio-Sciences,
University of Jammu, Jammu (J&K)-180 004.

and observation recorded for the duration of their sequential dives and surface pause after re-emergence using a stop-watch. Total of 1641 dive cycles (981 for Tufted duck and 660 for Common Pochard) were observed. Only one bird (of either of the two diving duck species) was observed at a time. During the present work only those dives were taken into consideration which were made for foraging. Divers make repeated foraging excursions from the surface to which they must return to breathe (Ydenberg 1986), though some distance away from where they dive. Thus the underwater time and the post-dive pause which is spent on the surface, completes a dive cycle. During a dive cycle, the bird under observation may get disturbed, by one way or the other on quite a few occasions, particularly during emergence at surface, thus either lengthening the post-dive pause or forcing the bird to dive. All such observations were deleted from the data so that we have a data set purely of free foraging dive cycles.

To compare the post-dive pause time to its preceding dive length time, all the observations were grouped that were made under similar dive length time (in seconds) and then the mean ± S.D. of all the post-dive pauses were calculated for each group of similar dive length (Table 1).

To analyse any correlation between dive length and post-dive pause, statistical method of Karl Pearson's co-efficient of correlation (r) was applied to the data-

$$r = \frac{\sum xy}{\sqrt{\sum x^2 \times \sum y^2}}$$

Where $x = (X-\bar{X})$ and $y = (Y-\bar{Y})$

X is the dive length,
Y is the mean post-dive pause time,
$\bar{X}$ is the mean dive length of the data,
$\bar{Y}$ is the mean pause time of the data,

To test the significance of the observed Co-efficient of Correlation (r), t-test has been applied as follows:

$$t = \frac{r}{\sqrt{1-r^2}} \times \sqrt{n-2}$$

Where 'n' is the d.f.

Regression analysis has also been worked out to estimate values of pauses (Y) at independent values of dive (X).

Regression equation of Y on X is expressed as follows:

$Y = a + bX$

X (dive) is the independent variable and 'a' and 'b' are constant having values of

a=7.17 and b= 0.26 in Tufted duck.

a=3.6 and b= 0.49 in Common pochard.

Result and Discussion

Table 1 and Fig. 1 summarizes comparative data on dive length and post-dive pause relation-

TABLE 1
COMPARATIVE ACCOUNT OF POST-DIVE PAUSE LENGTH TO ITS PRECEDING DIVE LENGTH IN THE TWO DIVING DUCK SPECIES IN LAKE MANSAR

Dive time (in seconds)	Pause time in Tufted duck Mean ± S.D	Pause time in Common pochard Mean ± S.D
6		7.33 ± 2.51
7		6.66 ± 2.08
8		7.66 ± 2.08
9		7.00 ± 3.82
10		8.75 ± 3.59
11	9.00 ± 0.00	10.25 ± 4.99
12	10.00 ± 0.00	13.33 ± 4.04
13	—	10.50 ± 4.94
14	9.50 ± 1.00	11.00 ± 4.21
15	12.75 ± 2.62	12.33 ± 4.21
16	12.50 ± 3.80	10.00 ± 1.41
17	9.54 ± 2.25	10.12 ± 5.20
18	12.40 ± 4.30	12.80 ± 2.28
19	14.98 ± 4.97	12.50 ± 3.50
20	15.78 ± 7.62	15.11 ± 1.83
21	13.53 ± 6.77	13.22 ± 1.39
22	12.03 ± 3.31	14.84 ± 2.70
23	12.90 ± 2.25	17.14 ± 4.52
24	15.59 ± 5.30	14.00 ± 3.81
25	13.27 ± 4.09	14.33 ± 4.16
26	13.23 ± 4.62	13.60 ± 3.13
27	13.90 ± 3.58	14.10 ± 3.69
28	13.36 ± 3.86	15.00 ± 4.69
29	11.35 ± 2.89	15.80 ± 1.78
30	14.18 ± 4.35	22.16 ± 2.40
31	19.75 ± 4.11	25.00 ± 6.85

ship in the two diving ducks *Aythya fuligula* and *A. ferina* in Lake Mansar. In both the species positive relationship has been worked out, i.e. r=0.88 in Common pochard and r=0.65 in Tufted duck, both of which are significant at 5% level (i.e. t > 0.05).

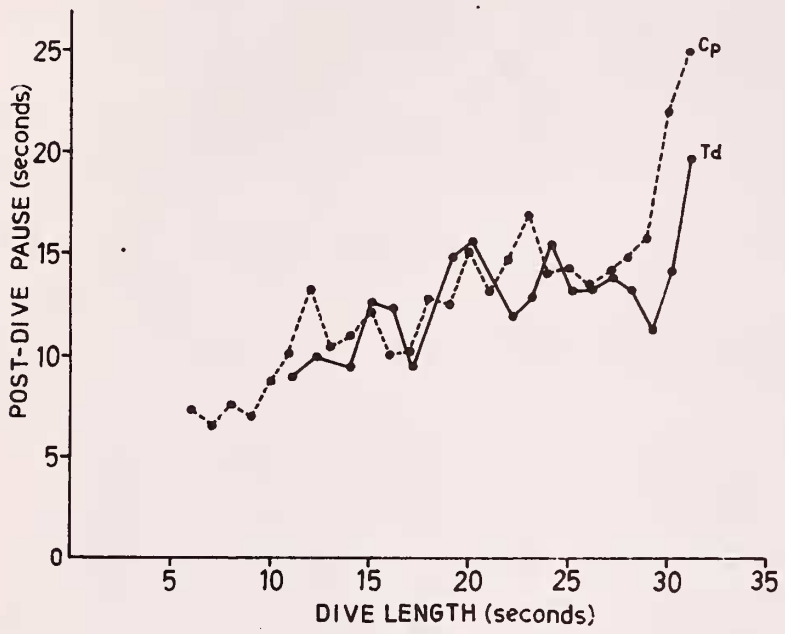

Fig. 1. Dive-pause relationship in the two diving ducks: Cp — Common pochard and Td — Tufted duck. Each point is the mean of 10 to 132 dive cycles.

Similar to our observation, Dewar (1924) has also shown positive relationship with significant increase in pause time with dive time in diving ducks and other divers (including loons, grebes, cormorants and auks). Positive relationship between dive and pause duration has also been worked out by Forbes (1985) in Western Grebe *Aecmophorus occidentalis*, and Stonehouse (1967) in cormorants *Phalacrocorax melanoleucos* and *P.carbo*. Houston and McNamara (1985) developed a general theory of central place foraging for single prey loaders that takes account of the fact that longer dives are followed by longer pauses. Data from a variety of species show that pause duration is directly related to the length of the preceding dive which strongly suggests that this is, at least, partly, recovery time during which respiratory gases are exchanged (Butler and Woakes 1979). Comparative data on dive and surface times suggest that different species, depending on their foraging ecology, allocate the recovery time from dives in different ways, such as, divers whose prey may escape or hide between dives (e.g. fish) may postpone recovery to dive more frequently until a series of dives has been completed. Divers whose prey are sedentary (e.g. shellfish) seem to complete much more of the recovery after each dive (Ydenberg 1986). Diving is energy expensive (Woakes and Butler 1983, 1986) and divers spend much time underwater. Time spent on surface is used for recovery from physiological effects (partial asphyxiation) which may be a consequence of diving and underwater life as also suggested by Ydenberg (1986) and Ydenberg and Forbes (1988). Alongside, body heat lost while underwater may be regained while on the surface after a dive as also suggested by Mac-Arthur (1984).

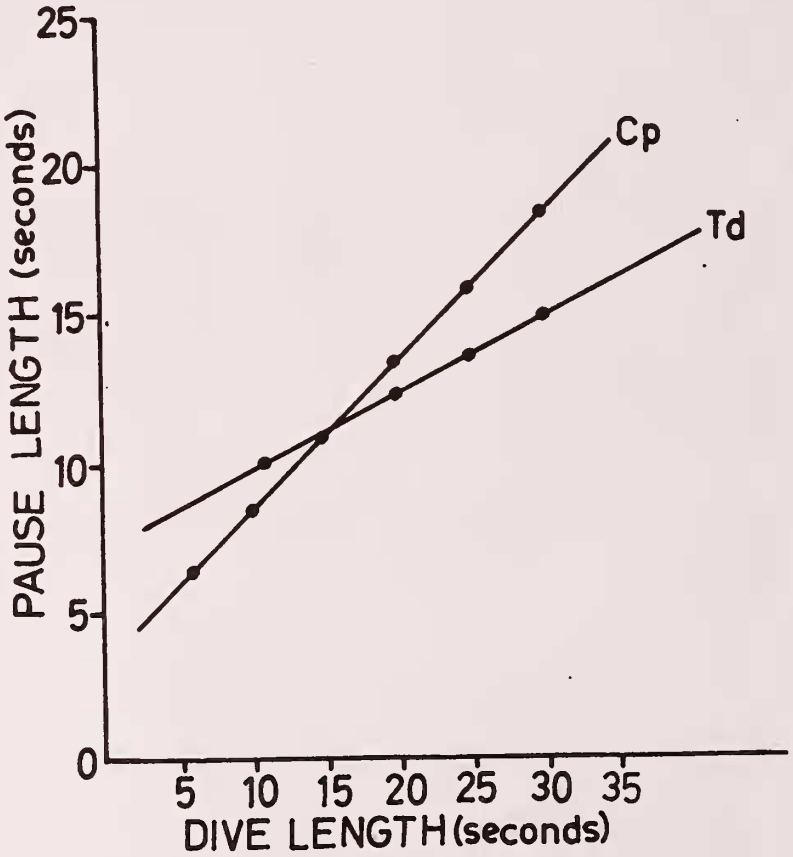

Fig. 2. A comparison of the dive-pause relationship in Common pochard (Cp) and Tufted duck (Td) by Regression analysis.

Of the two diving ducks, Common pochard shows more increase in pause time with increase in dive time than in Tufted duck, i.e. regression line for pause time is steeper in case of Common pochard than in Tufted duck (Fig. 2). This difference can be related to the difference in diet of the two species.

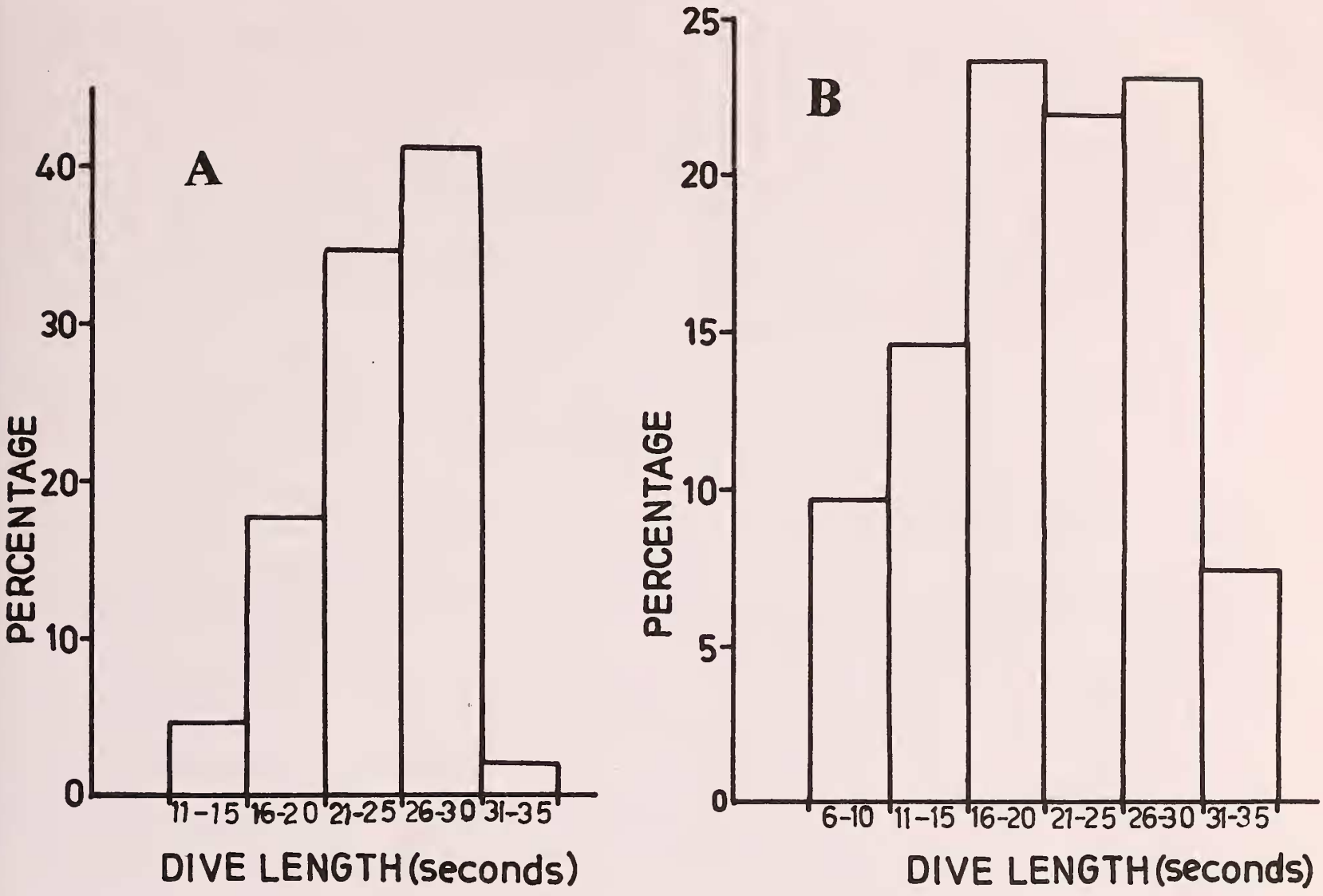

Fig. 3 Percentage of dives made at a frequency of 5 seconds in (A) Tufted duck; (B) Common pochard.

That Common pochard is more a vegetarian than the Tufted duck, is well documented by Ali and Ripley (1978). Ydenberg (1986) also explains that difference in observation of Dewar (1924) where steepest slope is for diving ducks as compared to other divers like mergansers, loons, grebes, cormorants, etc., is suggested to be due to different diets of the latter from former. The diving ducks generally feed on sessile or slow moving benthic prey such as shellfish and crustaceans (Nilsson 1972, Pehrsson 1976, Ali and Ripley 1978) whereas other species (mergansers, loons, grebes, cormorants) which capture fish in active pursuit. Ydenberg (1986) explains that short pauses *are advantageous* because prey may escape between successive dives.

When dive time of the two ducks is compared for same time (21 seconds and above), we find Tufted duck diving for this duration on 77.5% of the total observation (Fig. 3, A), whereas Common pochard does so for 52% of the total observations only (Fig. 3, B). The difference in dive duration is influenced by diet difference in the two species as already stated and also by the foraging decisions (Stephens and Krebs 1986) made while underwater, namely which prey to eat and which to neglect or how many prey to capture and how long to continue a search before surfacing. Houston and McNamara (1985) concluded that, for a diving bird, the decision policy, for accepting and rejecting prey items, is in favour of that which maximizes the rate of energy gain which makes the bird less and less selective as the dive progresses, because rejection becomes more and more costly.

Conclusion

Data collected and analysed thus shows positive relationship between dives and post-dive

pause, i.e. with increase in dive time, post-dive pause also increases. Such relationship in dive-pause is well supported by reports of other investigators also. Dive-pause relationship is more in Common pochard than in Tufted duck and is well explained by the difference in diets of the two species. Further it is observed that on an average Tufted ducks go for longer duration of dives and on more occasions than Common pochard do, which can be related to their differences in diet and foraging decisions made while underwater.

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